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Wireless Bandwidth Utilization for key remote monitoring scenarios

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Key Scenarios:

1. The impact on Bandwidth requirements for various Continua uses cases for remote monitoring and assisted living.

2. The impact on Bandwidth requirements of moving from one video conference to five concurrent video conferences in a single location (e.g Assisted living facility). Does upgrading from standard def to high def affect that?

3. The impact of transmitting radiological images via 3g cellular networks for teleconsultation.

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Executive Summary

Bandwidth for Remote Monitoring

- Bandwidth requirements for various Continua uses cases for remote monitoring and assisted living. Based on Continua compliant standards based WAN interfaces like XML, SOAP, HTTPS.

No.	Use Case	# of times /day	Total Data/ patient/day	# of patients	Total WAN traffic (bytes)
1	COPD patient regime				
1.1	Pulse Ox reading	4	8,200	20	274,000
1.2	Blood pressure reading	1	2,300	20	156,000
1.3	Weight reading	0.5	1,000	20	130,000
	TOTAL				560,000
2	CHF patient regime				
2.1	Blood pressure reading	1	2,300	20	211,000
2.2	Weight reading	0.5	1,000	20	185,000
	TOTAL				396,000
3	Diabetes				
3.1	Blood glucose reading	4	12,800	20	470,000
4	PERS Event (voice call)	1		3	0
5	10 Standard questions	1	1,540	60	87,000
	TOTAL				1,513,000

A typical assisted living scenario will generate ~1.5 MBytes of data/day. With 600kbps (75 KBytes/sec upload speed, this scenario will generate 20 seconds of data (.02% of total available bandwidth)

Video Conferencing Bandwidth - Mobile

No	Use Case	Network	Resolution	Bandwidth Kbps 15-30 FPS	Total Bandwidth for 2 way video conf	3G cellular impact @ 500kbps upload
1	1 Video conference	Mobile	QVGA (320x240)	Video 177 - 354 Audio 48 - 128 Total 225 - 482	2 way Video Conf BW needed = 450-964 kbps	Will consume ~90% of bandwidth for 1 to 1 video conferencing
2	1 Video conference	Mobile	CIF (352x240)	Video 195 - 390 Audio 48 - 128 Total 243 - 518	2 way Video Conf BW needed = 486-1,036 kbps	Will consume ~90% of bandwidth for 1 to 1 video conferencing
3	5 Video conference	Mobile	QVGA (320x240)	Video 177 - 354 Audio 48 - 128 Total 225 - 482	2 way Video Conf BW needed = 2,250-4,820 kbps	1 to 5 video conferencing will not be possible with 3G networks 4G networks (like WiMAX and LTE can support this)
4	5 Video conference	Mobile	CIF (352x240)	Video 195 - 390 Audio 48 - 128 Total 243 - 518	2 way Video Conf BW needed = 2,430-5,180 kbps	1 to 5 video conferencing will not be possible with 3G networks 4G networks (like WiMAX and LTE can support this)

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Video Conferencing Bandwidth - Landline

No	Use Case	Network	Resolution	Bandwidth kbps 30 FPS	Total Bandwidth for 2 way video conf	Landline impact @ 12Mbps download and 4Mbps upload
1	1 Video conference	Landline	SD - SVGA (800x600)	Video 1,745 Audio 48 -192 Total 1,793 - 1,937	2 way Video Conf BW needed = 3.6 - 3.9 Mbps	Will consume ~15% of downstream and ~50% upstream bandwidth
2	1 Video conference	Landline	SD - XGA (1024x768)	Video 2,860 Audio 48 -192 Total 2,908 - 3,052	2 way Video Conf BW needed = 5.8 - 6 Mbps	Will consume ~25% of downstream and ~75% upstream bandwidth
3	1 Video conference	Landline	HD 720 (1280x720)	Video 3,350 Audio 48 -192 Total 3,398 - 3,542	2 way Video Conf BW needed = 6.8 - 7.0 Mbps	Will consume ~30% of downstream and ~87% upstream bandwidth
4	1 Video conference	Landline	HD 1080 (1920x1080)	Video 7,540 Audio 48 -192 Total 7,600 - 7,730	2 way Video Conf BW needed = 15.2 - 15.4 Mbps	Not possible, since this will consume ~63% of downstream and ~187% upstream bandwidth
5	5 Video conference	Landline	SD - SVGA (800x600)	Video 1,745 Audio 48 -192 Total 1,793 - 1,937	2 way Video Conf BW needed = 18 - 19 Mbps	Not possible, since this will consume ~75% of downstream and ~225% upstream bandwidth

Impact of transmitting radiological images via 3g cellular networks for teleconsultation

No	Use Case (images)	Raw bit rate	Original size	Compres sion	Compressed size	3G cellular impact @ 500kbps upload
1	Digital mammography	4000x5000x 12	30 MB	100:1	300 KB = 2.4 Mbits	~ 5 seconds to upload
2	Digital mammography	4000x5000x 12	30 MB	20:1	1.5 MB =12 Mbits	~ 24 seconds to upload
3	MR	512 x 512 x24	786 KB	20:1	40 KB = 320 Kbits	~ 1 seconds to upload
4	CT	512 x 512 x24	786 KB	10:1	80 KB = 640 Kbits	~ 2 seconds to upload
5	Chest radiograph	2048x2048 x24	12 MB	20:1	620KB = 5 Mbits	~ 10 seconds to upload
6	Angiography	1024x1024x 24	3 MB	20:1	157KB = 1.25 Mbits	~ 3 seconds to upload

Supportive Material

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- Majority of cell phones today are QCIF screen resolution (176x144bits), there are higher resolutions like QVGA (320x240) that are currently being used for mobile video applications. The bandwidth requirements almost double.

- Sprint or a Verizon phone, depending on the location and technology available could have the following data rates available:

CDMA2000 1X (1.25 MHz Channel)	
Peak	153 kbps (DL) 153 kbps (UL)
Average User Data Rates	60 - 100 kbps

CDMA2000 1xEV-DO Rel. 0 (1.25 MHz Channel)	
Peak	2.4 Mbps (DL) 153 kbps (UL)
Average User Data Rates	300 - 700 kbps (DL) 70 - 90 kbps (UL)

| CDMA2000 1xEV-DO Rev. A (1.25 MHz Channel)	
Peak	3.1 Mbps (DL) 1.8 Mbps (UL)
Average User Data Rates	600 - 1400 kbps (DL) 500 - 800 kbps (UL)

- Other Carriers (at&t, T-Mobile and others) offer similar data rates.

- A **videoconference** (also known as a *videoteleconference*) is a set of interactive telecommunication technologies which allow two or more locations to interact via two-way video and audio transmissions simultaneously. It has also been called **visual collaboration** and is a type of groupware.

- It differs from videophone in that it is designed to serve a conference rather than individuals.

- Videoconferencing is a very useful technology for telemedicine and telenursing applications, such as diagnosis, consulting, transmission of medical images, etc., in real time in countries where this is legal.

- Using VTC, patients may contact nurses and physicians in emergency or routine situations, physicians and other paramedical professionals can discuss cases across large distances. Rural areas can use this technology for diagnostic purposes, thus saving lives and making more efficient use of health care money.

- Special peripherals such as microscopes fitted with digital cameras, videoendoscopes, medical ultrasound imaging devices, otoscopes, etc., can be used in conjunction with VTC equipment to transmit data about a patient.

SD vs HD quality

- **Standard Definition (HD)**
    - Since 199?
    - Up to 768x432 pixels
   - Up to 30 frames per second
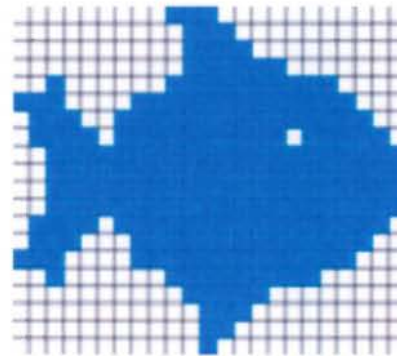
- **High Definition (HD)**
    - since approx 2006
    - Up to 1920x1080 pixels
    - Up to 60 frames per second
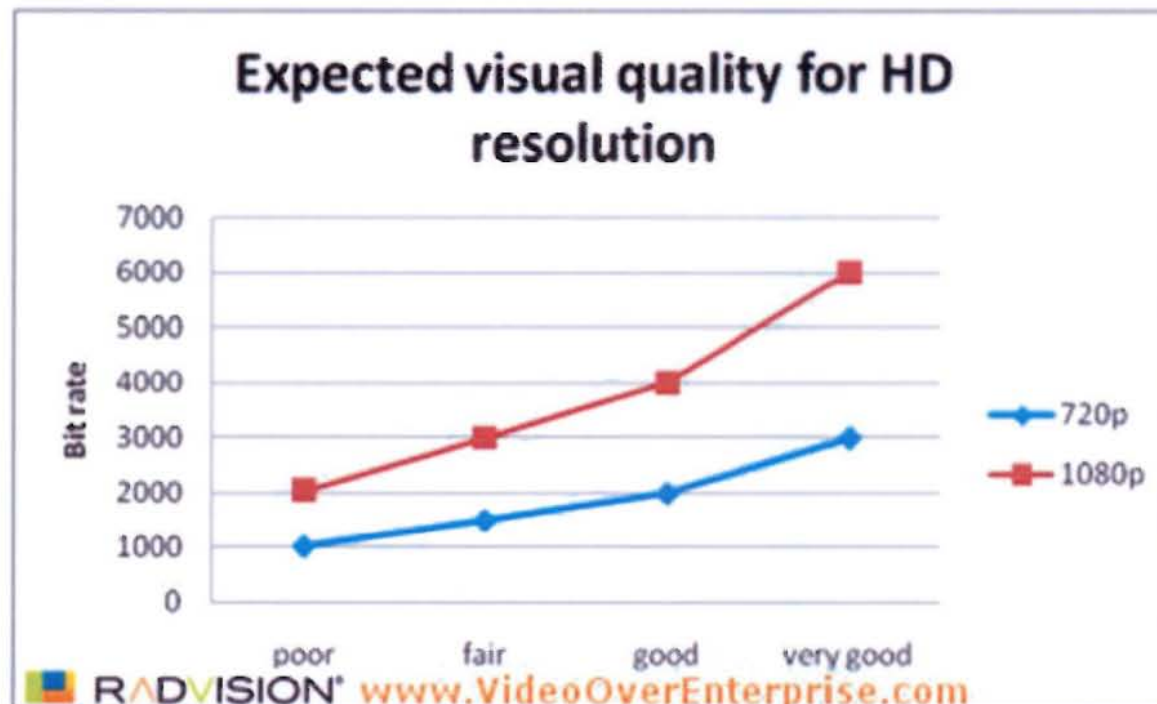   - Allows for eye-contact
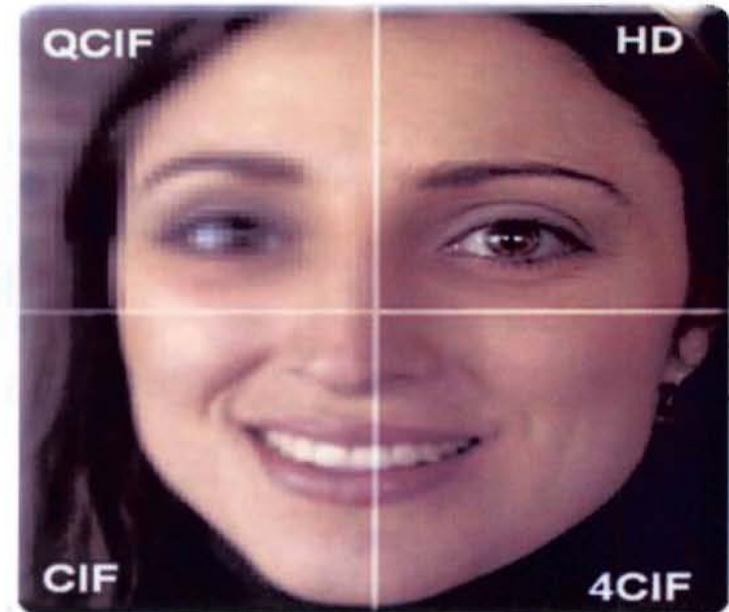
- For SD quality, 30 frames per second video conference scene (known as "talking head") we need at least 1.5-2 Mbps bandwidth. The bit rate depends on several factors (such as the quality of the camera or lens, the quality of the encoder, the complexity of the scene itself). The graph below shows the visual quality that the end user can expect with a given bandwidth using H.264 encoder.

- Common links between sites range from 384Kbps to 2Mbps. An enterprise and/or user that has invested in HD, expects to get "the HD experience", but is strongly affected by his peers.
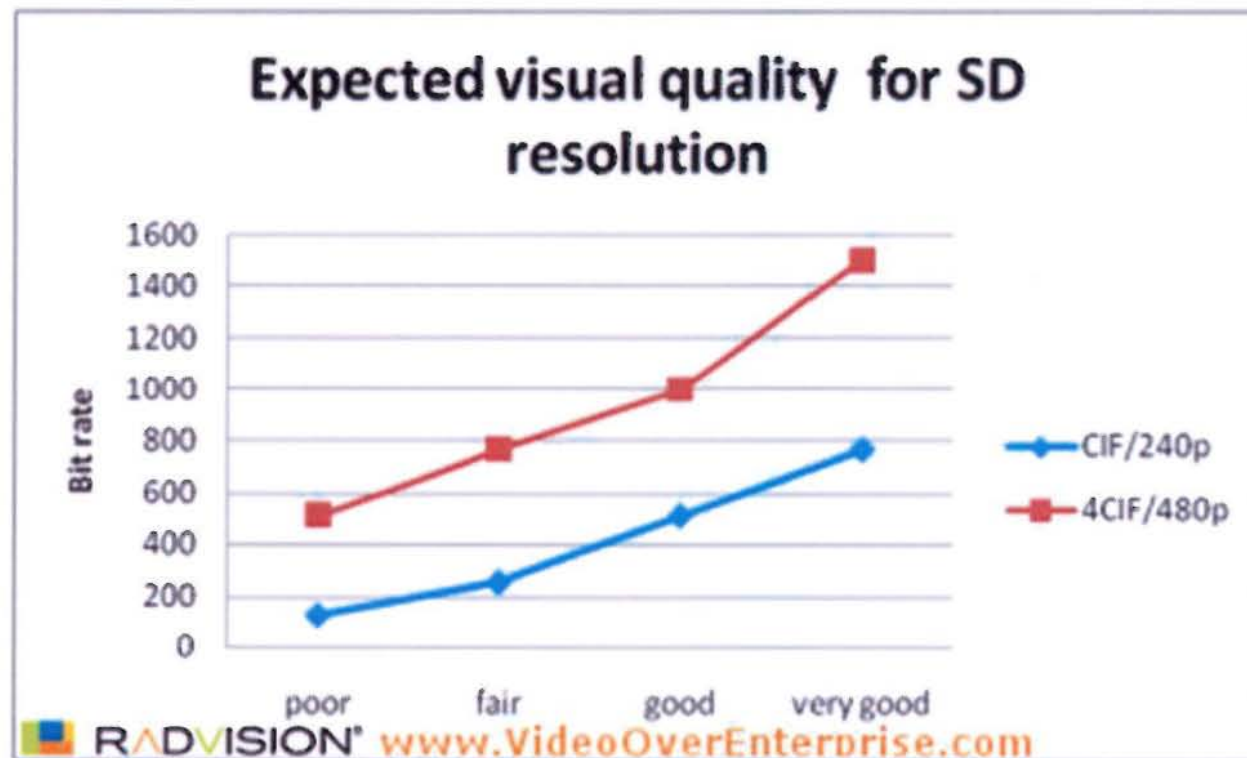
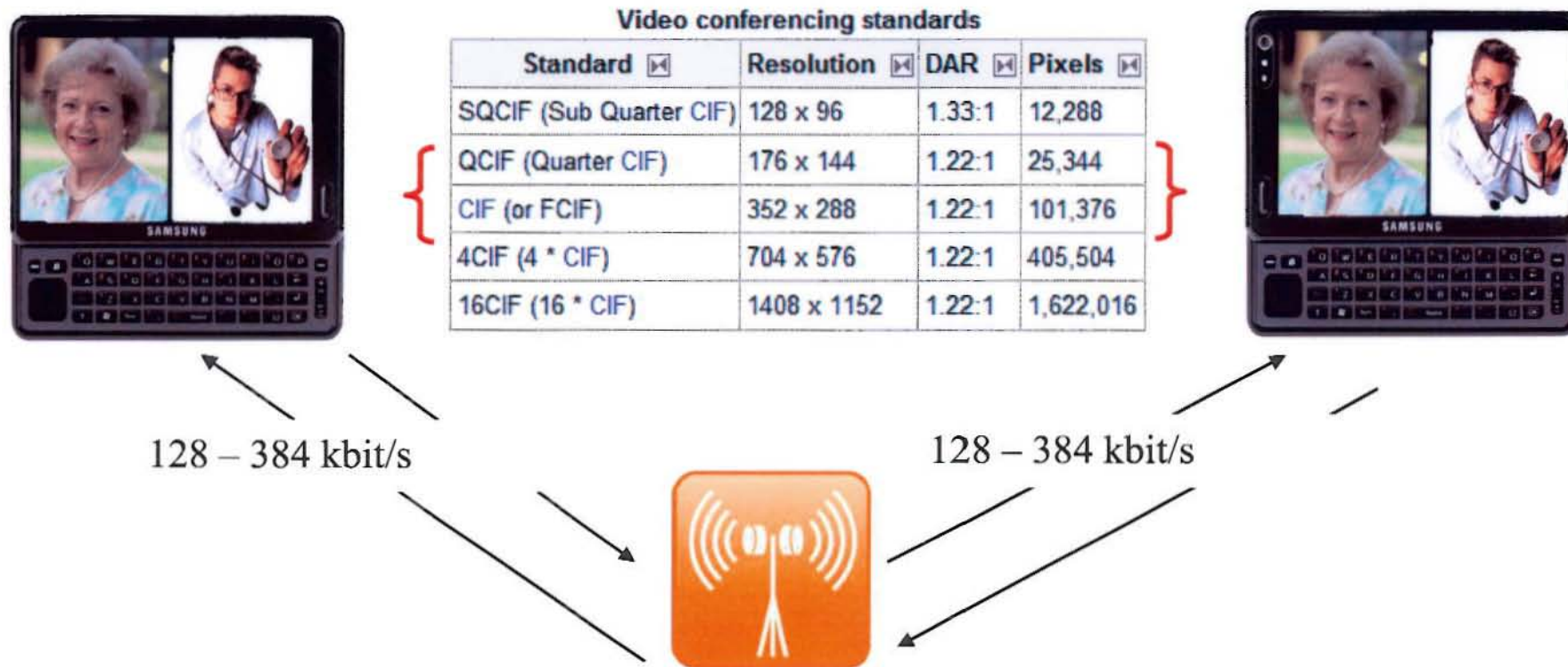Visual quality resolution vs. bandwidth using a H.264 encoder for SD

- To accommodate high quality video conferencing, an enterprise will have to invest a lot in its IP network.

- For full HD 1080p video conferencing we need 6Mbps in each direction, so we will need at least 12Mbps for 1 bi-directional video conferencing.

- Looking at the required bandwidth for 720p or 1080p makes it is clear why the HD video conferencing is not spreading that fast and is still more of an executive toy rather than a mass communication tool. The video conference market today is still filled with SD endpoints and the common links between sites range from 384Kbps to 2Mbps. An enterprise that has invested in HD, expects to get "the HD experience", but is strongly affected by his peers
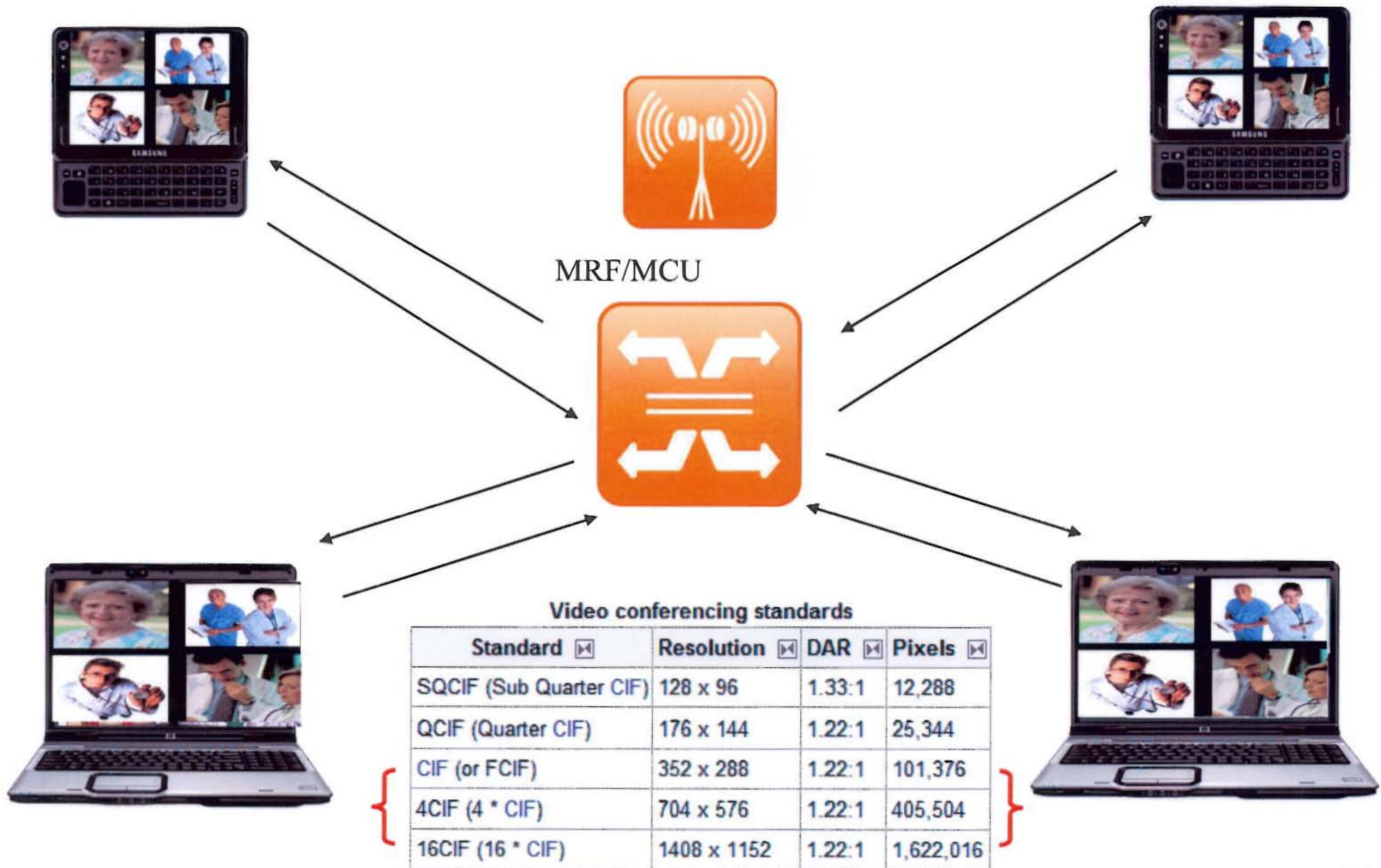

Visual quality resolution vs. bandwidth using a H.264 encoder for HD

Videoconferencing Use Case - Peer-to-Peer

Video conferencing standards

Standard	Resolution	DAR	Pixels
SQCIF (Sub Quarter CIF)	128 x 96	1.33:1	12,288
QCIF (Quarter CIF)	176 x 144	1.22:1	25,344
CIF (or FCIF)	352 x 288	1.22:1	101,376
4CIF (4 * CIF)	704 x 576	1.22:1	405,504
16CIF (16 * CIF)	1408 x 1152	1.22:1	1,622,016

128 – 384 kbit/s

128 – 384 kbit/s

Quality is determined by the Frame Rate per seconds – Full Motion require 30FPS

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Use Case – Many-to-Many

MRF/MCU

Video conferencing standards

Standard ⋈	Resolution ⋈	DAR ⋈	Pixels ⋈
SQCIF (Sub Quarter CIF)	128 x 96	1.33:1	12,288
QCIF (Quarter CIF)	176 x 144	1.22:1	25,344
CIF (or FCIF)	352 x 288	1.22:1	101,376
4CIF (4 * CIF)	704 x 576	1.22:1	405,504
16CIF (16 * CIF)	1408 x 1152	1.22:1	1,622,016

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Compression Ratios : Irreversible DICOM JPEG and JPEG-2000 compression must only be used at the compression ratios and for the modalities and anatomical areas shown below. Irreversible DICOM JPEG must only be used on 8 and 12 bit images.

a. Computed Radiography / Digital Radiography (CR/DR) - The standard defines the following irreversible compression ratios for CR/DR imaging categories.

♦ **Body Imaging – DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 30:1.**

♦ **Breast Imaging– DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 25:1.**

♦ **Chest Imaging– DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 30:1.**

♦ **Muscular Skeletal Imaging –**

- DICOM JPEG to a maximum compression ratio of 30:1

- DICOM JPEG-2000 to a maximum compression ratio of 20:1.

♦ **Pediatric Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 30:1**

b. Computed Tomography (CT)

The standard defines the following irreversible compression ratios for CT imaging categories with a slice thickness of 5mm or greater1

♦ **Angiography - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 15:1.**

♦ **Body Imaging –**

- DICOM JPEG to a maximum compression ratio of 15:1

- DICOM JPEG-2000 to a maximum compression ratio of 10:1.

♦ **Chest Imaging– DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 15:1.**

♦ **Muscular Skeletal Imaging – DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 15:1.**

♦ **Neuroradiology –**

- DICOM JPEG to a maximum compression ratio of 12:1

- DICOM JPEG-2000 to a maximum compression ratio of 8:1.

♦ **Pediatric Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 15:1**

c. Ultrasound (US)

The standard defines the following irreversible compression ratios for US imaging categories.

♦ **Body Imaging including Obstetrics – DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 12:1.**

♦ **Breast Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 12:1.**

♦ **Muscular Skeletal Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 12:1.**

♦ **Pediatric Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 12:1.**

d. Magnetic Resonance (MR)

The standard defines the following irreversible compression ratios for MR imaging categories.

♦ **Angiography - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Body Imaging – DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Chest Imaging– DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Breast Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Muscular Skeletal Imaging – DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Neuroradiology - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1.**

♦ **Pediatric Imaging - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 24:1**

e. Nuclear Medicine (NM)

The standard defines the following irreversible compression ratios for NM imaging categories.

♦ **All anatomical regions - DICOM JPEG and DICOM JPEG-2000 to a maximum compression ratio of 11:1**

http://car.ca/Files/Standard_Lossy_Compression_EN.pdf

http://www.rcr.ac.uk/docs/radiology/pdf/IT_guidance_LossyApr08.pdf

http://www.lebox.com/fuentes/Alemanes_compresion.pdf

MODALITY	COMPRESSION RATIO
Chest radiography	10:1
Skeletal radiography	10:1
CT (all areas)	5:1
Mammography	20:1
MR	5:1
US	10:1
Digital angiography	10:1
Radiotherapy CT	No compression

Summary of recommended compression rates in Canada, England, and Germany

	Canada	England	Germany
Radiography	20-30	10	10
Mammography	15-25	20	15
CT	8-15	5	5-8
MR	16-24	5	7
RF/XA	n/a	10	6

http://www.entrepreneur.com/tradejournals/article/134676840_3.html

It is apparent in the scientific literature that different imaging modalities generate image types that vary in matrix sizes, ranging from 128 x 128 for nuclear medicine images and 256 x 256 for MR images to 512 x 512 for CT images, 2048 x 2048 for CR/DR images and 4000 x 5000 for digital mammography images. Additionally, these images have a bit depth ranging from 8 to 24. These characteristics play a major role in determining the spatial and contrast resolution of digital images.